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THE SPACE STATION: CANADA'S CONTRIBUTION

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THE SPACE STATION: CANADA'S CONTRIBUTION

ISSUE DEFINITION

For many years the United States has been actively, and generally successfully, involved in the exploration of space. It has sent unmanned and manned space craft into orbit and brought them back. It has landed men on the moon and seen them return safely to earth. The space shuttle has demonstrated the feasibility (and the dangers) of the reuseable space craft. The U.S. now feels that it is time to begin exploiting the unique features of space - near-zero gravity, near-perfect vacuum and lack of atmospheric interference present on earth. It notes that only a permanently-manned space station will enable mankind to reap the benefits of this special environment in terms of scientific research, technological development and commercial enterprises. In 1984, President Reagan committed the United States to building a space station within a decade and invited Canada, Japan and the European Space Agency to join in this ambitious program. At the Shamrock Summit in March 1986, Prime Minister Mulroney announced that Canada was accepting the invitation.

The Canadian government agreed to develop and operate one of the station's mission-critical elements - the Mobile Servicing Centre (MSC). The opportunity to build on our already well-established space industry, the potential for spin-offs from the advances in robotics and artificial intelligence engendered by this effort and future access to the space station for scientific research and manufacturing were cited as reasons for Canada's becoming involved. The estimated cost of Canadian participation was originally set at $800 million. The revised estimate is $1.2 billion until the year 2000.

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Canada has already begun work on the MSC, based on the original design criteria set out by NASA. Recently, however, Congress reduced the space station budget from the $2.45 billion that NASA had requested to $1.9 billion for the 1990-91 fiscal year. This amount will be increased by only 10% per year and a cap of $2.6 billion per year has been imposed. These budget restrictions, along with some misgivings about the engineering of the proposed station, led Congress to order NASA to review the design and adjust the program to meet these new financial constraints. The review process was originally due to be completed by 22 January 1991 but this deadline was subsequently extended for another 30 days. Officials of the Canadian Space Agency have been closely monitoring these changes and their effect on the Canadian contribution. They expect to release a full assessment of the issue this summer.

On Monday, 3 June 1991, the U.S. House Appropriations Committee dealt a further serious blow to the project by voting to kill the entire $2 billion budget for next year. The full House debated the issue and, on 5 June, voted to reverse the decision and approve the funding. The Senate must still vote on the budget, but the White House is expected to veto any appropriations bill which does not include Space Station funding. It is, therefore, expected that, at least for FY 1991-92, the program will continue.

BACKGROUND AND ANALYSIS

A. The Space Station

The U.S. space station will not be the world's first, since, in 1973-74, Skylab, which could house astronauts for up to three months at a time, was already in orbit above the earth. Between that time and the 1984 decision to build a space station, the U.S. concentrated on developing the Space Shuttle (or STS - space transportation system). In the meantime, the Soviet Salyut program has provided permanent, manned space station facilities since 1971. The Soviets have also launched the MIR, which is a central element in their permanently-manned (as opposed to permanent, manned) space station.

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The U.S. space station program, as it was originally conceived, was an ambitious and innovative one. The station was expected to perform a wide range of functions, serving as:

- a laboratory in space, for scientific research and the development of new technologies;
- a permanent observatory, with elements in low inclination and polar orbits, from which to observe Earth and the universe;
- a transportation centre where payloads and vehicles are stationed, processed and deployed to their destinations;
- a servicing facility where payloads and vehicles are maintained, repaired and refurbished;
- an assembly facility where large space structures and systems are assembled and checked out;
- a facility to enable manufacturing in space, where the unique environment enhances commercial opportunities;
- a storage depot where payloads and parts are kept on orbit for subsequent use;
- a staging base for possible future space projects, such as a permanent lunar base, a manned mission to Mars, a manned survey of the asteroids, a manned scientific and communications facility in geosynchronous orbit, or unmanned planetary probes.

Comments from the U.S. military have indicated that the station might also be used for military research and testing at some time. These comments brought Canada's participation into question and resulted in a delay in negotiating the agreement covering Canadian involvement. Since the text of an agreement has now been agreed upon, the issue has presumably been resolved. As a result of subsequent budget cuts to the space station program, and the resulting need to redesign the system, debate has been renewed over the prime objectives or goals that should be set. Some feel that commercial objectives (such as manufacturing of unique compounds) should have priority, while others feel that life sciences should predominate.

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In its original configuration, the structure of the space station base resembled a large rectangle of metal trusses. These trusses, approximately 94.5 metres (310 feet) on the vertical side, by 45.7 metres (150 feet) on the horizontal side, would have been carried into space on the Shuttle and assembled by the Canadian MSC. Another truss across the middle of the rectangle would have supported the modules, which would have been large cylinders in which crew members lived and worked. The various modules would have been connected to each other by a series of nodes (spaces adjacent to, but not part of, the module - something like a vestibule) and tunnels. This arrangement would have facilitated both the easy movement from one module to another and the addition of further modules as the station grew. Power for the space station would have been provided by a hybrid system employing both photovoltaic cells [25 kilowatts (kw)] and solar dynamic heat engines (50 kw). This total of 75 kw is a very high level of power compared to that of previous space craft, and is, in fact, enough energy to run 25 all-electric homes. Fifty kilowatts would have been dedicated to users of the station and 25 kw to basic "house-keeping" requirements. Figure 1 (page 6) is a diagram of the major elements of the original space station design. The 1991 redesigned version of the Space Station is considerably smaller than the original. It is 108m long (vs 150m) and has only six, rather than eight, pairs of solar panels, with a resultant cut in electrical power supply (to 56 kw from 75 kw). It will house only four, rather than eight astronauts, at a time and will be capable of transmitting only about one-sixth as much information per minute to earth. Clearly, the number and range of experiments that can be carried out with this new configuration will be inferior to what were originally planned.

NASA is now reassessing the order in which elements of the station will be taken into orbit by the Shuttle. It was originally planned to have flights every 45 days during the assembly of the station but it is certain that the *Challenger* disaster and current budgetary problems at NASA will alter this estimate. In addition, the new design for the station seems to be more modular in nature, with less of the construction done in space. It is now estimated that about 25, not 35, shuttle flights would be required to complete the assembly. There is currently some discussion of

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the need to develop a new heavy-lift launch vehicle, so that reliance on shuttle launches could be reduced.

In its original plan, NASA anticipated that the Shuttle would arrive at the assembly point and the crew would assemble elements of the station in the cargo bay. These elements would then have been swung out into space by the Canadian Mobile Servicing Centre arm mounted on the Shuttle. Early flights would have concentrated on the truss framework, the electrical power, communications and guidance equipment. At the end of these early flights, the Shuttle crew would literally have left the partially built station hanging in space and returned to Earth. It was expected that assembly would begin in January 1993 (now estimated as 1996). Canada's MSC is currently scheduled to be on the fourth flight. Once the base was complete, subsequent flights would have put the various platforms associated with the station into orbit. The new schedule, based on the redesign, would see all elements in place by sometime in 2000. Even with the new dates and the redesign, the assembly process would not change.

B. Canada's Contribution - The Mobile Servicing Centre (MSC)

As noted earlier in this report, Canada agreed to take part in the space station project only if its involvement would consist of more than producing a single piece of hardware and would continue after the station becomes operational. It is with this in mind, as well as other important considerations (see D, page 8), that Canada proposed to design, develop, build and operate the Mobile Servicing Centre (MSC) for the space station. The MSC, shown in Figure 2, will consist of a base structure with room for payloads, replacement units, utilities and thermal control equipment. It will also have two "Canadarms" (or a Space Station Remote Manipulator System, as it will be known). The arms will be supplied with special purpose, dextrous manipulators, end-effectors and servicing tools. External and internal control stations, from which the crew can control its operation, will also be part of the MSC. As well, Canada is studying the possibility of developing a larger MSC maintenance depot, where the MSC itself would be maintained, as part of its effort.

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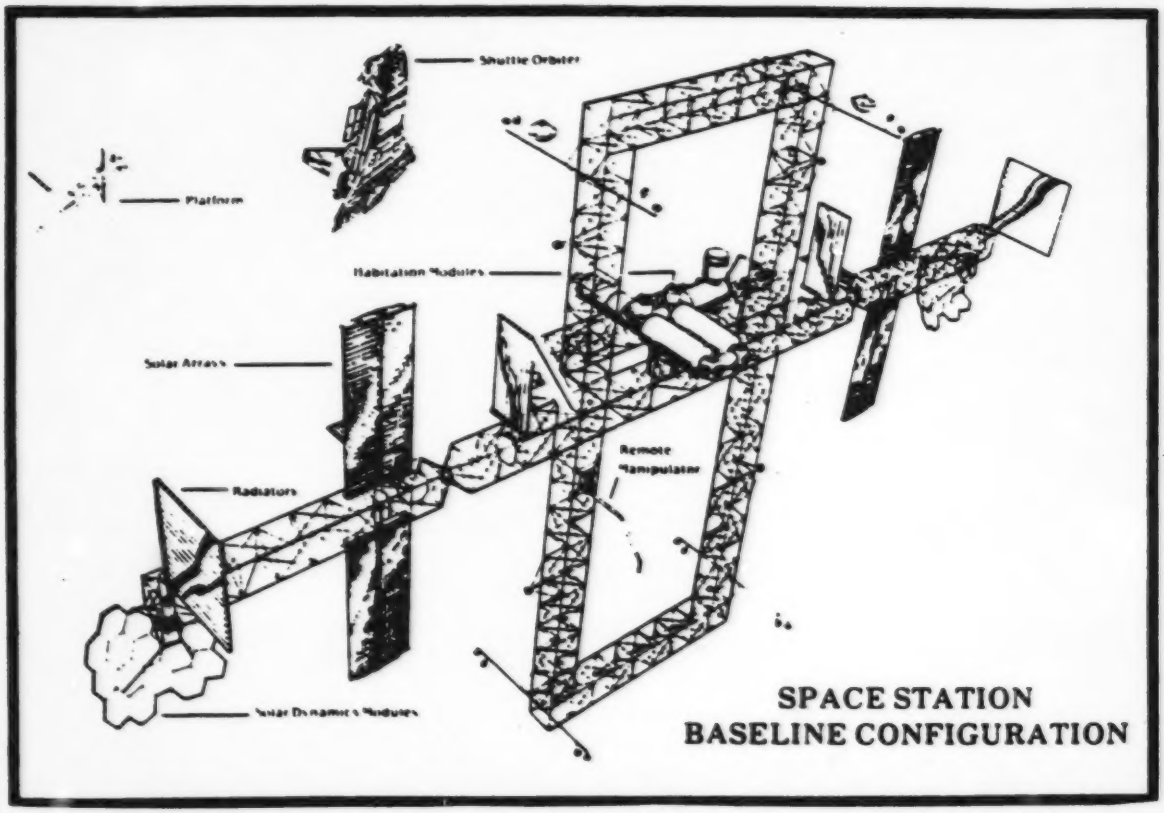
FIGURE 1: THE SPACE STATION



Source: Office of Space Station, NASA Headquarters, *The Space Station: A Description of the Configuration Established at the Systems Requirements Review (SRR)*, Washington, D.C., June 1986.

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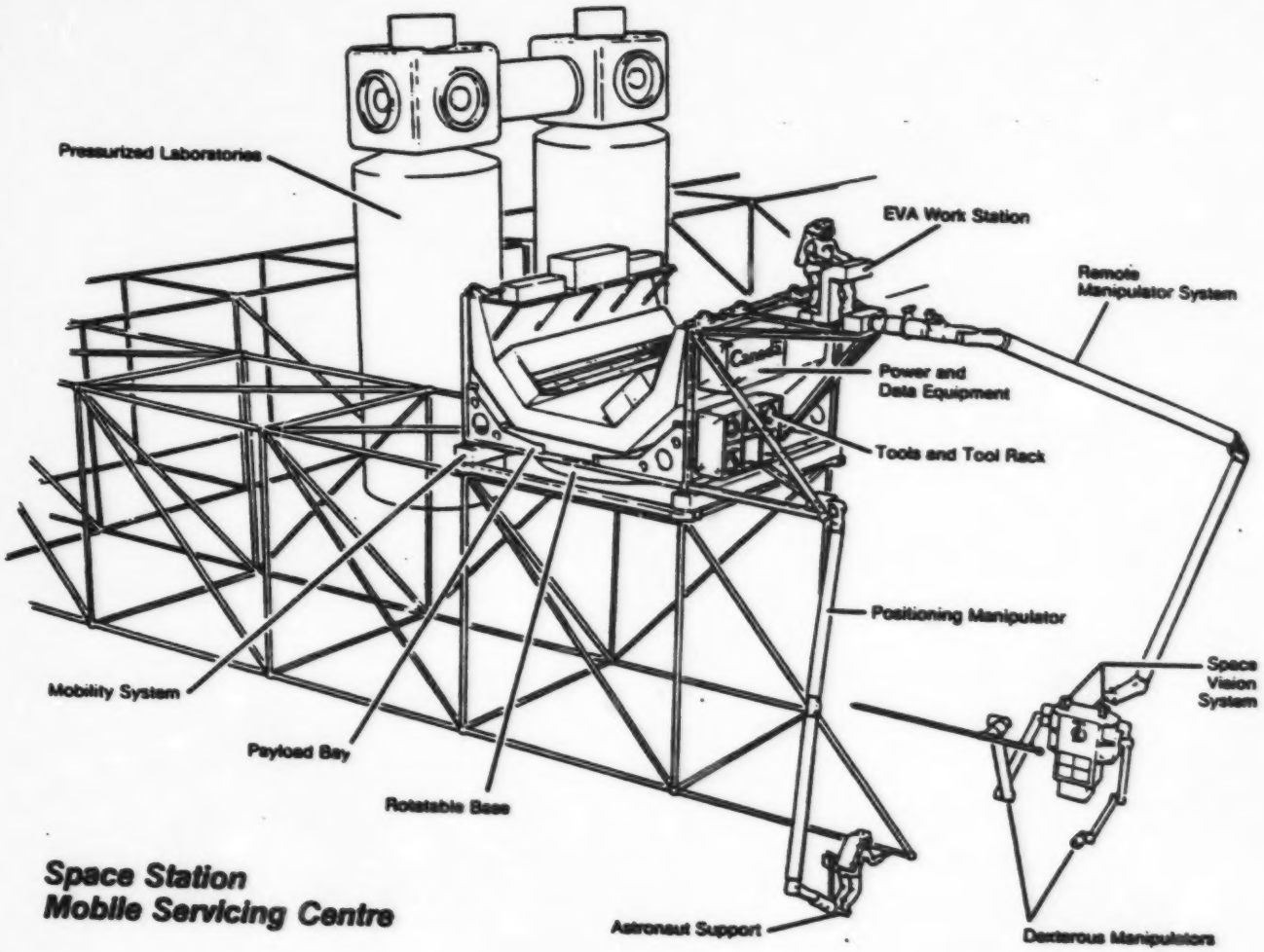
FIGURE 2: SPACE STATION MOBILE SERVICING CENTRE



Source: National Research Council, The Space Station, Canada's Contribution, 1986.

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Once in orbit, the MSC was expected to be an important element in the construction of the station and in its day-to-day operation. It is expected, in fact, to have the predominant role in assembling and maintaining external portions of the station, externally servicing attached payloads, moving equipment and supplies around the station, deploying and retrieving satellites and other payload items, and supporting astronauts during extravehicular activities.

As previously noted, the Space Station is now being redesigned and these changes may alter some of the functions of the MSC as well. Canadian officials have apparently been assured, however, that major redesign of the MSC will not be required.

C. Other International Contributions

1. The Japanese Experimental Module (JEM)

Japan, like Canada, is proposing to participate in the space station project. Its contribution will be a laboratory to accommodate general scientific and technology development research activities including microgravity studies. The JEM will consist of several parts including a pressurized module, an exposed facility, an airlock joining those two elements, a local remote manipulator and an experiment logistics module (ELM). The ELM attaches to the laboratory and can be removed, returned to Earth to deliver experiments and products made in space, refilled with new materials and returned to the station to be reattached to the JEM. The ELM is being made compatible with Japan's own launch vehicle, the H-2, which is expected to be ready for use in the mid-1990s. Japan has agreed to spend about $2 billion on its space station contribution.

2. The European Space Agency's Pressurized Module (ESA Module)

The European Space Agency is studying an attached, pressurized, multi-purpose laboratory as its contribution to the space station. This facility is designed for international use principally in the fields of fluid physics, life sciences research and materials research. Like the JEM and the U.S. laboratory and habitation modules, the ESA module will include storage capacity and accommodation for what is

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known as "crew safe-haven capability". In other words, in the event of an emergency, there would be sufficient supplies and accommodation for the space station crew to await rescue.

Both ESA and NASA are also studying polar-orbiting platforms which would be used for earth, ocean, solar and atmospheric observations, plasma physics research, remote measurements and environmental monitoring. These platforms would be self-powered and would be maintained or refuelled with propellant for manoeuvering either *in situ* or at the space station base.

D. Why Should Canada Participate?

The answer to this question is not simple. There are, in fact, many reasons put forward to justify Canadian participation in this ambitious space program. Among them are achieving international prestige, securing an entrée into important new high-tech fields, generating technological spin-offs on Earth and buying long-term access to the space environment for Canadian researchers. In the short term, the technical and economic spin-offs here on Earth are probably the most significant, together with the creation of a pool of knowledgeable scientists and industrialists in the emerging technologies. Dr. Larkin Kerwin, head of the Canadian Space Agency, notes that $1 billion in economic spin-offs have already flowed to Canadian business, and that this figure could go as high as $5 billion. Many of the technologies developed for the space station, especially in the fields of robotics and automation, will have terrestrial applications, including work in "hostile" environments such as the nuclear industry, mining and offshore resource development.

In a 1986 report, the Canadian Institute for Advanced Research discussed Canada's participation in the following terms:

> Participation in the Space Station is analogous to joining a fitness club - an economic fitness club. Agreement to provide a component of the Station is the membership fee. If Canada is going to get any tangible benefit from being in the club, though, it must have the ability and the financial resources to use the facilities. Equally important, it will need to use its

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> newly acquired strength and agility in all aspects of its economic life. If it does not, the membership fee will be wasted.

This report cautions that resources must be put into all aspects of our space effort if maximum benefit is to be derived. To achieve this, it suggests that our space station program be viewed as having four essential elements, namely:

- production and operation of the Mobile Servicing Centre (MSC);
- a Space Station user support program;
- a technology development program; and
- a technology exploitation program.

If all four elements were effectively supported, the report predicts that Canada could benefit considerably from its investment, as it evolves into a knowledge-based economy. The program would:

- stimulate and partially finance the creation of a long-term applied research base within Canadian industry;
- facilitate emergence of new, knowledge-intensive industries, an important factor in Canada's economic development;
- assist in the creation of a pool of highly skilled researchers, whose expertise would contribute to technological development; and
- promote the establishment of productive long-term relationships between industry and universities.

The NRC's 1986 report on the subject provides a list of the opportunities presented to Canada as a space station user, once we have "paid our dues":

- *Space Technology.* Space Station is well-suited to developing and testing complex satellite systems, automation, robotics, manipulators and space structures before these are committed to regular operations.
- *Materials Processing.* The use of microgravity for developing new or improved products for the elec-

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tronics, pharmaceutical and metal processing industries offers the potential to make this one of the more significant economic application. Interest among Canadian industries is growing in the use of Space Station laboratories for these purposes.

- *Space Science.* Space scientists in Canada study the earth, its atmosphere, outer space and astronomy. Space Station will provide additional bases for observation and research.

- *Communications.* The use of Space Station will permit on-orbit check-out of communications satellites as well as the construction of larger ones. Eventually, it will be possible to service communications satellites in their respective orbits.

- *Life Science and Bio-Medicine.* The development of new pharmaceuticals and biotechnology processes will be possible, as will an increased understanding of the long-term adaptation of humans to a space environment, which will be important if humans are to spend extended periods in space.

- *Remote Sensing.* Canada, more than most countries, needs to monitor her extensive land mass and resources. New remote sensing systems will have greater power, as well as improved data-handling and transmission capabilities. Using Space Station as a base, Canada could develop and test these systems prior to their operational use in polar orbit.

During the summer of 1988, negotiations involving Canada, ESA, Japan and NASA were concluded. A treaty governing the Space Station was signed on 29 September 1988. Canada is to have access to 3% of the station's research resources. With the scaled-down version now being proposed, Canada would appear to be getting much less for its more than $1 billion contribution. Some within the scientific community are now suggesting that we should be reassessing the benefits of our participation.

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CHRONOLOGY

20 May 1982 - The Space Station Task Force was set up at NASA to identify mission requirements, define the space station concept and coordinate NASA research centres interested in the concept.

July-August 1982 - NASA contracted with aerospace firms to identify user requirements in space science, technology development commercial activities and, initially, national security. Canada, Japan and ESA countries did similar independent reviews.

August 1983 - NASA's final briefing to senior, cabinet level space committee on the space station concept.

25 January 1984 - The President announced that the U.S. would have a permanently-manned space station by the end of the decade.

18 March 1986 - Prime Minister Mulroney announced Canada's acceptance of the invitation to participate in the space station program.

16 January 1987 - External Affairs Minister, the Right Honourable Joseph Clark, sent a letter to the U.S. administration expressing Canada's concern over reports that the U.S. military wanted to use the space station for military experiments.

December 1987 - Canadian and U.S. negotiators agreed on the text of a Memorandum of Understanding governing Canadian participation in the Space Station Project. It was finalized after Cabinet and Congressional approval early in 1988.

21 April 1988 - The Ministers of Regional Industrial Expansion and Science and Technology (Mr. de Cotret) and Science and Technology (Mr. Oberle) announced the government's decision to commit $1.2 billion over 15 years to the realization of the Mobile Servicing System (MSS) for the U.S. Space Station.

29 September 1988 - An international agreement governing the construction and operation of the Space Station was signed by the USA, Japan, Canada and the European Space Agency.

1 March 1989 - The federal government announced that the new national space agency will be located in Montreal. Dr. Larkin Kerwin, President of the National Research Council,

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will be the head of the agency. The Space Station Management Program will become part of the Agency's mandate.

10 May 1990 - Bill C-16; An Act to Establish the Canadian Space Agency and other matters in relation to space, was given Royal Assent.

October 1990 - Congress cut the NASA Space Station budget and ordered a review of the entire program. This review would involve important design and scheduling changes and was to be complete by 22 January 1991.

January 1991 - NASA was given a 30-day extension to complete its review of the Space Station program.

3 June 1991 - The U.S. House Appropriations Committee voted to cancel the entire $2 billion budget for the Space Station, for the 1991-92 fiscal year.

5 June 1991 - The full House of Representatives rejected the Committee recommendation and approved funding for 1991-92.

SELECTED REFERENCES

Dotto, Lydia. "Back to the Future." *Canadian Business*, Vol. 59, November 1986, p. 64-71.

National Aeronautics and Space Administration. *The Space Station, A Description of the Configuration Established by the Systems Requirements Review*. Washington, D.C., June 1986.

National Research Council of Canada. *The Space Station: Background Paper*. Ottawa, March 1986, 11 p.

Space Station Committee. The Canadian Institute for Advanced Research, *Canada and the Space Station: A Report to the Government of Canada*. 1985, 31 p.

Space Station Committee. The Canadian Institute for Advanced Research, *Canada's Participation in the Space Station: Objectives and Management*. October 1986, 11 p.